Courses offered in M.Sc:

Course no.	Title of the course	Credit
1st Semester		
PPH 501	Principles of Plant Physiology	3+1
PPH 502	Plant Water Relationship	2+1
PPH 503	Crop Physiology	2+1
PPH 504	Mineral Nutrition	2+1
PPH 505	Hormonal Regulation of Plant Growth and Development	2+1
2nd Semester		
PPH 551	Plant Metabolism-I	1+0
PPH 552	Physiological and Molecular Responses of Plants to Abiotic Stresses	2+1
PPH 553	Physiology of *in vitro* Cell Differentiation	2+1
PPH 554	Genome Organization in Higher Plants	2+1
PPH 555	Experimental Plant Physiology	0+1
3rd Semester		
PPH 601*	Plant Metabolism-II	1+1
PPH 602	Seed Physiology	2+1
PPH 603	Biological Nitrogen Fixation	2+0
PPH 604	Senescence and Abscission	2+0
PPH 649	Seminar-I	1+0
4th Semester		
PPH 651*	Physiology of Crop Plants – Specific Case Studies	2+0
PPH 652*	Physiological and Molecular Aspects of Photosynthesis-carbon Assimilation	2+1
PPH 653	Physiology of Reproduction	2+0
PPH 699	Seminar-II	1+0

Syllabus of courses at PG level:

M.Sc. Courses

PH 501 Principles of Plant Physiology 3+1

Theory

UNIT I: Photosynthetic apparatus, chloroplast structure , ultra structure of thylakoids, pigment structure and function, Photo systems, mechanism of light absorption, chloroplast electron transport chain.

UNIT II: Photochemical process, photochemical reaction, photophosphorylation – cyclic and non-cyclic, mechanisms of ATP synthesis, and concept of quantum yield.

UNIT III: CO_2 fixation and reduction in Calvin cycle, CO2 fixation in C4 plants; CO2 fixation in CAM plants and its significance. Difference among C3, C4 and CAM plants Photorespiration and its relevance. Effect of environmental factors on photosynthetic rates. Significance of photosynthesis in plant growth, development and bioproductivity.

UNIT IV: Glycolysis , preparatory and pay-off phases, Fermentation. Kreb's cycle, electron transport chain, oxidative phosphorylation, chemiosmotic hypothesis, balance sheet of ATP yield, Respiratory quotient, respiratory inhibitors. Growth and maintenance respiration.

UNIT V: Hormonal concept of growth and differentiation, Definition and classification of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals.

UNIT VI: Site of synthesis, biosynthetic pathways, metabolism and physiological roles of individual group of hormones- Auxins, Gibberlins, cytokinins, Abscisic acid and Ethylene, Brassinosteroids, Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture. Stress and hormones with special reference to ABA .

UNIT VII: Enzyme characteristics, classification, specificity of enzymes, Mechanism of action of enzymes, enzyme kinetics, Factors affecting enzyme activity, Enzyme inhibitors.

Practical:

Extraction, separation and quantification of plant pigments, Quantification of O_2 evolution during photosynthesis, Auxins bioassays- auxins effect on rooting of cuttings, apical dominance, Gibberellins bioassays-GA effect on germination of dormant seeds, Cytokinin effect on senescence, ABA effect on stomatal movement, Measurement of respiration rate, Effect of respiratory inhibitors.

PPH 502 Plant Water Relations 2+1

UNIT I: Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential and its different components..

UNIT II: Mechanism of water uptake by roots and its transport in roots, aquaporins.

UNIT III: Water loss from plants-driving force for transportation, evapotranspiration

UNIT IV: Structure of stomata, stomatal movements;. Role of hormones and ions in stomatal movement.

UNIT V: Factors affecting the rate of transpiration, water use efficiency of crops, antitranspirants.

Practical:

Measurement of soil water status, Measurement of plant water status: Relative water content, water saturation deficits Chardakov's test. Determination of the rate of transpiration from a leaf, Determination of stomatal frequency, Determination of stomatal index, Role of antitranspirant in the regulation of transpiration, Role of growth regulators in stomatal movement.

PPH 503 Crop Physiology 2+1

Theory

UNIT I: Crop growth analysis, key growth parameters.

UNIT II: Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.

UNIT III: Source-sink relationships, Translocation of photosynthates and factors influencing transport of sucrose, Physiological and molecular control of sink activity – partitioning efficiency and harvest index.

UNIT IV: Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.

UNIT V: Plant ideotypes.

UNIT VI: Simple physiological yield models- Duncan's. Monteith's, and Passioura's model.

UNIT VII: Crop physiological aspects of rice, wheat, pulses, oil seeds, jute, potato and tea.

Practical:

Plant sampling for leaf area and biomass estimation, analysis of growth and yield parameters – LAD, NAR. CGR, LAI, LAR, SLA, partioning efficiency, HI, Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted and realized, Computer applications in plant physiology, crop productivity and modeling.

PPH 504 Mineral Nutrition 2+1

Theory

UNIT I: Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.

UNIT II: Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.

UNIT III: Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulations.

UNIT IV: Molecular physiology of micronutrient acquisition, Examples of genes encoding mineral ion transporters. Strategies adopted by plants to acquire and transport minerals under deficient levels.

UNIT V: Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties.

UNIT VI: Breeding crop varieties for improved nutrient efficiency. Plants' responses to mineral toxicity.

Practical

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels, Quantification of pigment levels, enzyme activities.

PPH 505 Hormonal Regulation of Plant Growth and development 2+1

Theory

UNIT I: Definition and classification of plant growth regulators : Hormones, endogenous growth substances and synthetic chemicals. Endogenous growth regulating substances other than hormones. Brassinosteroid, triacontanol, salicylate, polyamines, jasmonates.

UNIT II: Discovery, site of synthesis, bio-assay, biosynthetic pathways, mechanism of action, Physiological effects of individual group of hormones – Auxins, Gibberellins, cytokinins, Abscisic acid, Ethylene and Brassinosteroids.

UNIT III: Signal perception and signal transduction, hormone binding receptors, hormone induced changes in gene expression and specific functions of Auxin – cell elongation, Gibberellins – germination of dormant seeds, cytokinins – cell division and retardation of senescence of plant parts, Abscisic acid – stomatal closure and induction of drought resistance and Ethylene – fruit ripening. Specefic signaling pathways of Auxins, Gibberellins, cytokinins, ABA, ethylene and brassinosteroids.

UNIT IV: Interaction of hormones in regulation of plant growth and development processes, Rooting of cuttings, flowering, apical dominance, morphogenesis and molecular aspects of control of reproductive growth and development.

UNIT V: Synthetic growth regulators: Classification, their effect on plant growth and development, Practical utility in agriculture and horticulture.

Practical

Extraction and colorimetric estimation of IAA from plant tissues, Bio-assays of different plant growth regulators, Effect of auxins and Gibberellins on seedling growth, Effect of Gibberellins on germination of dormant seeds, Effect of kinetin on lettuce seed germination under dark, Effect of plant growth regulators on different physiological processes (Photosynthesis, respiration etc), Effect of IBA and NAA on rooting of cuttings, Role of ABA and kinetin on stomatal regulation, Study on chlorophyll retention by kinetin, Induction of senescence by ethylene.

PPH 551 Plant Metabolism I 1+0

UNIT I: Structure and physiological functions of cell wall and cell membrane, special reference to lipid bilayer.

UNIT II: Structure and functions of carbohydrates, Structure of lipids- Storage, protective and structural lipids.

UNIT III: Structure and functions of nucleic acid: DNA, RNA.

UNIT IV; Pentose phosphate pathway and its significance,

UNIT V: Allosteric regulation : homotropic and heterotropic regulation, Isozymes and their application in plant science.

PPH 552 Physiological and Molecular Responses of Plants to Abiotic Stresses 2+1

Theory

UNIT I: Stress, strain concept and terminologies. Classification of different kinds of abiotic stresses.

UNIT II: General features of drought stress. Temporary and permanent wilting, Morphological and physiological responses to drough, Drought resistance mechanisms: Escape and dehydration postponement (Drought avoidance), Dehydration tolerance. Compatible solutes and osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait.

UNIT III: Molecular responses to water deficit : Signal perception and signal transduction in drought stress. Expression of regulatory and functional genes and significance of gene products.

UNIT IV: Stress and hormones : Stress signaling molecules. Role of ABA in stomatal closure. Oxidative stress : Reactive Oxygen Species (ROS) ; Generation of ROS in plants – Fenton reaction and Haber-Weiss reaction. Scavenging mechanisms: Enzymatic (SOD, catalase, peroxidase, ascorbate peroxidase, glutathione reductase etc) and non-enzymatic anti-oxidants [Ascorbate (Vit. C), Tocopherol (Vit. E), carotenoids, glutathione etc].

UNIT V: Salinity : Alkalinity and salinity. Salinity effects at cellular and whole plant level. Effects of salinity on growth, yield and some physiological processes of crop plants. Species and varietal variation in salt tolerance. Molecular mechanism of salt tolerance : Salt stress perception and signal transduction.

UNIT VI: Metal stress : Aluminium and cadmium toxicity. Physiological processes affected by aluminium and cadmium. Alleviation of heavy metal stress by various technologies. Role of Phytochelatins.

Practical

Measurement of Relative water content (RWC) in leaf, Measurement of Electrical conductivity (EC) of different salt solutions, Determination of membrane injury (MI) and Membrane stability index (MSI), Effect of moisture and salinity stress on seed germination and seedling growth, Measurement of chlorophyll stability index (CSI) in response to drought and salinity, Effect of ABA on stomatal closure, Measurement of proline, Measurement of peroxidase and catalase activity, Screening techniques for salt tolerance, microscopic study of aerenchyma in *Nymphaea* sp.

PPH 553 Physiology of *in vitro* Cell Differentiation 2+1

Theory

UNIT I: Morphogenesis: The cellular basis of growth and morphogenesis, cytodifferentiation.

UNIT II: The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.

UNIT III: Introduction to *in vitro* methods : Terms and definitions, Use of growth regulators, Beginning of *in vitro* cultures in our country (ovary and ovule culture , *in vitro* pollination and fertilization), Embryo culture, embryo rescue after wide hybridization and its application, Endosperm culture and production of triploids.

UNIT IV: Introduction to the processes of embryogenesis and organogenesis and their practical applications : Clonal Multiplication of elite species (micropropagation) – axillary bud, shoot tip and meristem culture. Haploids and their applications. Somaclonal variations and applications.

UNIT V: Introduction to protoplast isolation : Principles and applications. Testing of viability of isolated protoplast, Various steps in the regeneration of protoplast. Somatic hybridization – an introduction, Various methods for fusing protoplast, Use of makers for selection of hybrid cells. Practical applications of somatic hybridization

UNIT VI: Use of plant cells, protoplast and tissue culture for genetic manipulation of plant: Introduction to *Agrobacterium tumefaciens*. Tumour formation on plants using *A. tumefaciens* (Monocots versus Dicots), Root – formation using *A.rhizogenes.*

Practical

In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes, Effect of explant age on propagation potential, Effect of growth regulators (auxin, cytokinins and ethlyne) on callus induction, organogenesis, Somatic embryogenesis, Effect of growth conditions such as temperature and photoperiod on organogenesis, Single – cell suspension cultures.

PPH 554 Genome Organization in Higher Plants 2+1

Theory

UNIT I: Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autoptetraploids and polyploids.

UNIT II: Gene and gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept.

UNIT III: Mitochondrial and chloroplastic genome organization and regulation of gene expression.

UNIT IV: Eukaryotic genome structure: Organization and replication, control of gene expression-transcription and post-transcriptional modifications, promoter analysis, concept of *cis* elements, transcription factors, function and role of RNA polymerases.

UNIT V: Genetic code and translation: deciphering the genetic code, tRNAs, ribosomes, initiation and termination of translation, translational and post-translational controls, Attenuation, Suppressor tRNAs.

UNIT VI: Mobile genetic elements, Structure and function of transposable elements, mechanism of transposition, special features of retroptransposons, repair and recombination.

Practical

Culturing and transformation of bacteria, Genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification, Culture of bactriophage, Studis on lytic and lysogenic phages.

PPH 555 Experimental Plant Physiology ` 0+1

Practical

UNIT I: Determination of nitrogen, phosphorous and potassium in plant samples.

UNIT II: Preparation of standard curve of D-glucose, Extraction and estimation of total soluble sugars and starch by Anthrone method.

UNIT III: Preparation of standard curve of BSA, Extraction and estimation of total protein by Lowry's method.

UNIT IV: Preparation of standard curve of L-Leucine, Estimation of total free amino acids from plant sample, Preparation of standard curve of L-proline, estimation of Proline from plant sample.

UNIT V: Estimation of antioxidative enzymes from plant sample.

UNIT VI: Estimation of chlorophyll and carotenoids from leaf sample.

PPH 601: Plant Metabolism II **1+1**

(Pre-requisite course : PPH 551)

Theory

UNIT I: Respiration as amphibolic pathway, Cyanide resistant respiration and its significance.

UNIT II: Biosynthesis of fatty acids, diacyl and triacyl glycerol.

UNIT III: Secondary metabolites and their significance in plant defence mechanism.

UNIT IV: Synthesis of sucrose and starch, Translocation of photosynthates and its importance in sink growth.

UNIT V: Crassulacean acid metabolism and its regulation.

UNIT VI: Glyoxylate cycle and its role in germinating seeds.

Practical

Estimation of starch and sugar from plant samples, Quantitative estimation of oil from different oil seeds, Estimation of acid value and saponification value of fat, Preparation of standard curve of gallic acid, Estimation of phenols, fractionation of seed storage protein.

PPH 602 Seed Physiology 2+1

UNIT I: Seed structure and function and types.

UNIT II: Chemical composition of seeds, physiological and biochemical changes associated with seed development, physiological maturity and its determination, environmental effect on seed development.

UNIT III: Seed dormancy and its causes, methods of breaking seeds dormancy.

UNIT IV: Pathway of movement of assimilates in developing grains of monocots and dicots.

UNIT V: Seed aging. Seed viability, physiological means to prolong seed viability, Seed vigour concepts; importance and measurement of invigoration; Physical basis and methods of invigoration.

UNIT VI: Seed priming and its effect on seedling establishment.

Practical:

Measurement of germination percentage and seedling growth of different quality of seeds, Determination of vigour and viability by TZ test, Role of GA in breaking dormancy of seeds, Effect of GA application on α-amaylase activity of seeds, Accelerated aging test of seed lots of different crops nder storage conditions, Studies on membrane leakage of seeds, Respiratory enzyme analysis for determining the vigour of seed lots: dehydrogenase enzyme, Study of lipid peroxidation.

PPH 603 Biological Nitrogen Fixation 2+ 0

UNIT I: A brief account of the nitrogen cycle- biological and non-biological nitrogen fixation- the flow of nitrogen between different global nitrogen pools.

UNIT II: Physiology of symbiotic nitrogen fixation system- structure and formation of nodule in legumes, Physiology of non-symbiotic nitrogen fixation by other microorganisms.

UNIT III: Structure and function of nitrogenase, hydrogenase and leg-hemoglobin, biochemical regulation of nitrogen fixation process.

UNIT IV: Nitrogen metabolism, inorganic nitrogen species (NO_2, NO_3, and NH_4) and their reduction to amino acids, protein and nucleic acids. GS (glutamine synthetase) and GOGAT (glutamine:2-oxoglutarate amidotransferase) pathway. Photorespiration loss of ammonia and its reassimilation, Nitrogen Use efficiency (NUE).

UNIT V: Significance of BNF in agriculture and forestry-sustainable agriculture and ecosystem.

PPH 604 Senescence and Abscission 2+0

Theory

UNIT I: Senescence**:** Definition of senescence and aging, types of senescence, biological significance of senescence. Senescence and programmed cell death (PCD), Sequential events leading to senescence in leaves, flowers, fruits and whole plant senescence. environmental factors influencing senescence. Physiological, biochemical and molecular aspects of senescence. Functional and ultrastructural changes in chloroplast, mitochondria and cell wall during senescence, hormonal regulation of senescence.

UNIT II: Molecular mechanism of senescence and aging : Gene expression during senescence. Senescence specific mutants. Signaling cascade during leaf senescence, Senescence associated genes and gene products.

UNIT III: Abscission: Phenomenon of abscission, abscission zone., Hormonal regulation of abscission, Gene activity during abscission, synthesis of new proteins during abscission. Signaling cascade during abscission.

PPH 651 Physiology of Crop Plants – Specific Case Studies 2+0

(Pre-requisite course : PPH 503)

Theory

UNIT I: Crop physiological aspects of rice, wheat, maize, sorghum, millets, sugarcane, pulses, oil seeds, cotton and potato Crops (Six to Eight Species could be chosen based on local importance).

UNIT II: Seed dormancy, photoperiodic and thermoperiodic responses.

UNIT III: Source-sink relationship, yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

PPH 652 Physiological and Molecular Aspects of Photosynthesis-Carbon Assimilation 2+1

(Pre-requisite course : PPH 501)

Theory

UNIT I: Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.

UNIT II: Physiological and biochemical aspects: chloroplast structure, development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, concept of quantum yield.

UNIT III: Photosynthetic carbon reduction cycle and its regulation. CO_2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation, CCM in photosynthetic bacteria, algae, Submerged Aquatic macrophages (SAM), C_4, CAM and single-celled C_4 organisms, C_3-C_4 intermediates, Ecological significance of CCM.

UNIT IV: Rubisco structure, assembly and kinetics, photorespiration and its significance.

UNIT V: Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress on photosynthesis.

UNIT VI: Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes, Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity. Conceptual approaches of expressing C_4 photosynthesis genes in C_3 species.

UNIT VII: Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo- inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and non-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE.

Practical

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O_2 evolution, Determination of rubisco activity, Determination of starch and sucrose content, Determination of photosynthetic rates –gas exchange,. WUE, Light, CO_2, VPD response curves, Determination of photorespiration by gas exchange, Genotypic/species differences in photosynthetic rates, Measurement of radiation, light interception.

PPH 653 Physiology of Reproduction 2+0

UNIT I: Definition of reproduction- different types of reproduction in plants; Organogenesis: Adventitious and axillary bud proliferation in plants.

UNIT II: Floral meristem and floral organ development, Floral evocation, Shoot apex and phase changes.

UNIT III: Floral induction and development-photoperiodism and its significance; Vernalization and hormonal control , Circadian rhythms.

UNIT IV: Photo morphogenesis: photo receptors, phytochrome, cryptochrome, physiology of flowering, Molecular genetics of floral development and floral organ differentiation:

UNIT V: Special aspect of plant development and differentiation –pollen germination and pollen tube guidance; Floral differentiation: Sex determination in plants, regulation of the events from pollination to fertilization.

UNIT VI: Self incompatibility and its genetic control, apomixis.